PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Inventor: Hugo MICHIELS

Attorney No.: MICH3003/JEK/JJC

Application No.: 10/685,576

Customer No.: 23364

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Examiner: Kurt FERNSTROM

Art Unit: 3712

For: IMPROVED TRANSDUCER

DECLARATION OF INVENTOR UNDER 37 C.F.R. 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Hugo Remi MICHIELS declare that:

1. I am the named inventor in the above-identified U.S. Patent Application Serial No. 10/685,576 ("the '576 application"). I am President of Sonitron nv, a leading manufacturer of piezoceramic audible components. I have participated in the design and development of a variety of acoustic components using piezoceramic-based transducers. Some of my designs are the subject of the following Belgian patents and pending U.S. patent applications, including:

Belgian patent 1,011,085

Belgian patent 1,011,559

Belgian patent 1,013,592

U.S. Patent Application 09/901,635 - TRANSDUCER

U.S. Patent Application 10/685,576 - TRANSDUCER

2. The present invention relates to a piezoelectric transducer for reproducing and recording sound. The transducer includes a membrane onto which is provided a generally circular piezoelectric element. The membrane is composed of a plurality of layers of which at least one layer is made of a polymer. The transducer is characterized in that the membrane is not round and lacks symmetry over 360° in relation to the shape of the piezoelectric element.

3. Prior art transducer systems typically have a membrane that is made of metal or a polymer. Examples of these systems are found in my Belgian patents 1,011,085, 1,011,559, and 1,013,592. Moreover, these systems typically have a piezoelectric element and membrane that both have a perimeter with the same shape. While these systems are good sound reproducers, their frequency response and harmonic distortion can be improved.

4. In devising the piezoelectric transducer according to the present invention, I have found that the flatness of the frequency response and harmonic distortion are improved when the shape of the perimeter of the piezoelectric element differs from the shape of the perimeter of the membrane, and when the membrane comprises a plurality of layers wherein at least one layer is made of a polymer.

5. As a result of the relationship between the perimeter shape of the piezoelectric element and the membrane, it has been found that a superior piezoelectric transducer is obtained when it has this relationship along with the membrane having at least one polymer layer.

6. Set forth in the appendix are drawing figures Fig. 1 and Fig. 2, and graphs I and II that I have prepared which illustrate the experimental results that compare the frequency response between piezoelectric transducers having piezoelectric elements and membrane with similar perimeters, and those with dissimilar perimeters according to the present invention.

According to these graphs, the samples are defined as follows:

Sample 1 (Fig. 1): Circular metal membrane (diameter 77mm) with a circular piezoelectric element (diameter 50mm), glued together with a silicone glue in a circular frame.

Sample 2 (Fig. 2): Rectangular metal membrane (78mm x 61mm) with a circular piezoelectric element (diameter 50mm) glued with silicone glue in a rectangular frame.

Sample 3 (Fig. 3): Circular composite membrane (diameter 77mm) with a circular piezoelectric element (diameter 50mm), glued with silicone glue in a circular frame.

Sample 4: Rectangular composite membrane (78mm x 61mm) with a circular piezoelectric element (diameter 50mm), glued with silicone glue in a rectangular frame.

7. From the frequency response curves of samples 1 and 2, it is clear that the combination of a rectangular membrane and a circular piezoelectric element results in a much flatter frequency response curve where the higher harmonics are seriously reduced in intensity.

8. From the frequency response curves of samples 3 and 4, it is readily apparent that the flatness of the curve is much better in the case of a rectangular membrane combined with a circular piezoelectric element.

9. In each of samples 3 and 4, a composite membrane was used with a polymer interlayer and two metallic outer layers. The effect of the polymer interlayer is clearly seen when these curves of samples 3 and 4 are compared with the curves of samples 1 and 2 such that the flatness of the curves of samples 3 and 4 are much flatter than those of samples 1 and 2.

10. In view of our diligent research, it has been found that because of the elastic resistance of the polymer interlayer, self-resonance of the composite membrane is substantially reduced. This results in a smoother frequency response curve, thereby yielding superior sound produced by the transducer according to the present invention over known transducer systems.

11. I have found that the dissimilarly shaped the perimeters of the piezoelectric element and membrane in combination with the polymer interlayer of the membrane, further yield the result of less harmonic distortion.

12. Also included in the appendix is graph III which compares the harmonic distortion of samples 3 and 4.

13. As can be seen in graph III, the total harmonic distortion is much lower for sample 4 that has a rectangular membrane and a circular piezoelectric element. This is particularly evident in the 400Hz-1kHz range. Once again, because of the favorable results from the dissimilarly shaped perimeters of the piezoelectric element and membrane, the transducer according to the present invention yields greater sound quality than in known transducer systems.

14. The appendix also includes drawing figures, Fig. 3 and Fig. 4, and corresponding graphs IV and V. In these figures and graphs, the functional course of the difference of the perimeter of the membrane and the perimeter of the piezoelectric element are shown.

15. In each of these graphs, it is clear that for the circular membrane/circular piezoelectric element combination, the function course is a linear function in the form of a straight line. On the other hand, for the rectangular membrane/circular piezoelectric combination, the functional course is non-linear with both increasing and decreasing portions.

16. Because the covered distance between the edge of the membrane and the edge of the piezoelectric element for the rectangular membrane/circular piezoelectric element combination is not constant, no standing waves with a concentrical nodal pattern will occur. This seriously diminishes the resonance.

17. I have considered U.S. Patent 4,439,640 (Takaya) taken in combination with U.S. Patent 5,838,805 (Warnaka et al.) cited by the Examiner. As acknowledged by the Examiner, the Takaya patent does not disclose or suggest a piezoelectric element having a perimeter with a different shape than the shape of the perimeter of the membrane.

18. Turning to the Warnaka patent, while it is true that this patent teaches a piezoelectric element having a variety of shapes, there is no mention of the substrate having a dissimilarly shaped perimeter wherein the substrate is not round and lacks symmetry over 360° in relation to

the shape of the piezoelectric element. In each embodiment shown wherein the piezoelectric element is adhered to the substrate, both the piezoelectric element and the substrate have generally the same shaped perimeter. In effect, the Warnaka et al. patent is silent on the specific relationship between the perimeter of the piezoelectric element and the perimeter of the substrate when the perimeter of the piezoelectric element has a non-circular shape.

19. According to the teachings of Warnaka et al. in the embodiment of Fig. 3, the piezoelectric element is partially or wholly surrounded by a plurality of motion couplers 25, 26, 27,28. The motion couplers limit the minimum thickness of the piezoelectric element and require a more complex manufacturing method compared with the glueing of a piezoelectric element onto a multi layer membrane, as recited in the present invention.

20. The substrate of the transducer of Warnaka et al., according to the embodiment of Fig. 4, is limited to two layers: one layer comprising a substrate of steel, aluminum, or brass, and a second layer comprising a motion coupler such as brass. On the contrary, the membrane according to the present invention is a multi layer membrane wherein one layer is a polymer layer. The Warnaka et al. patent fails to disclose or suggest this fundamental feature of the membrane according to my invention, and hence cannot be considered to possess the superior harmonic distortion results obtained from my invention.

21. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

29 April 2005
Date

Inventor Hugo MICHIELS

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APPENDIX

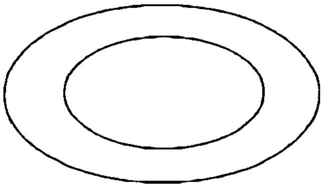


Fig. 1

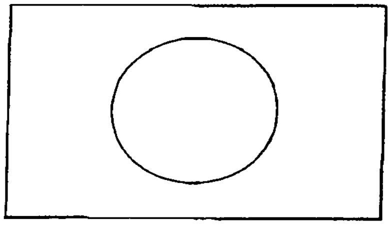


Fig. 2

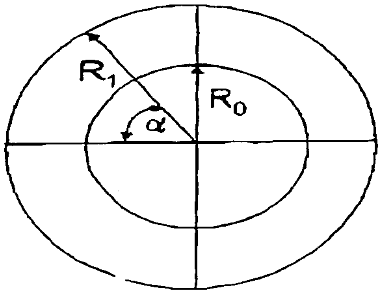


Fig. 3

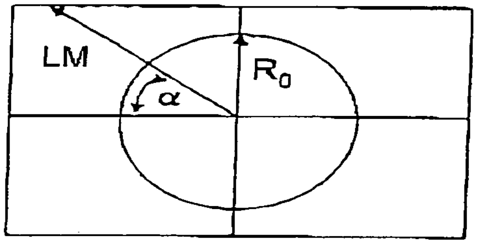
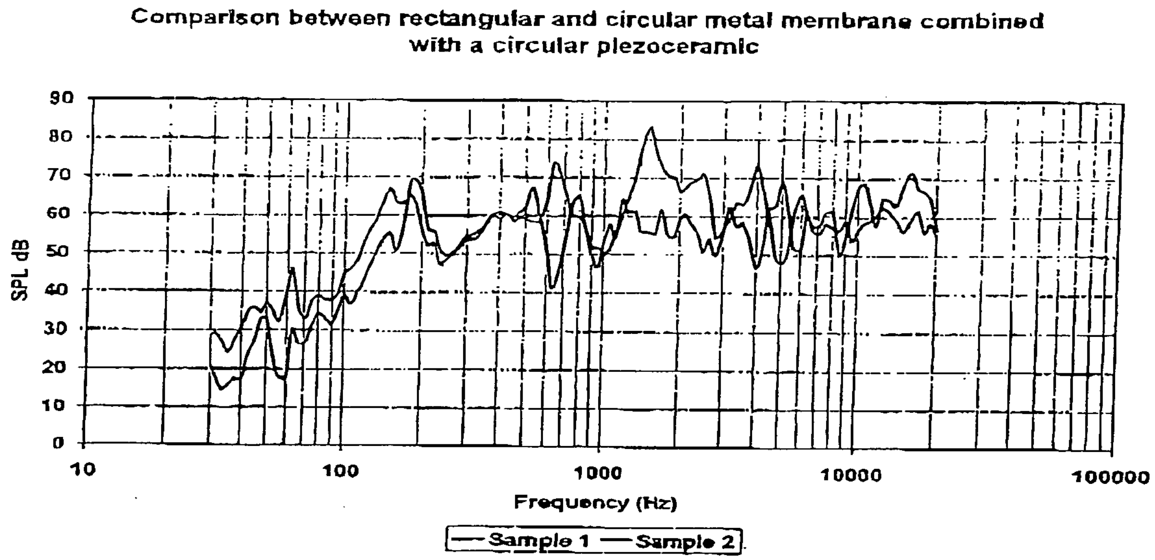
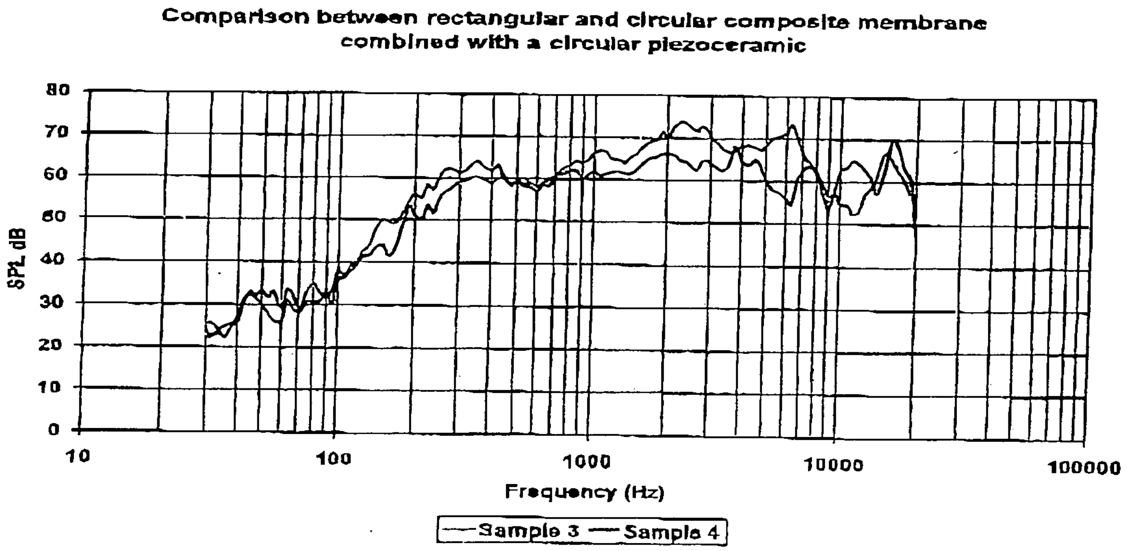


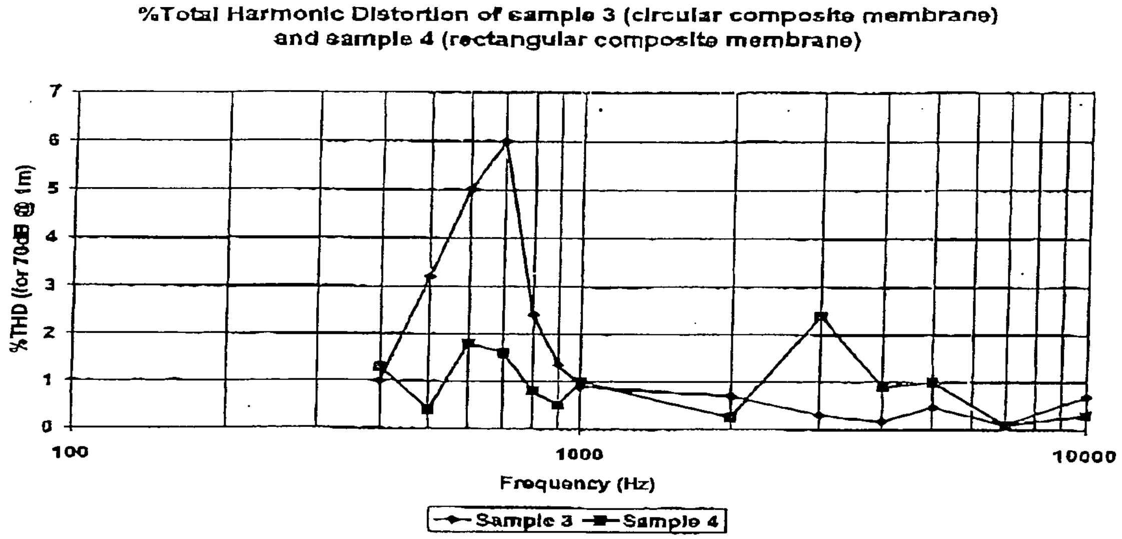
Fig. 4



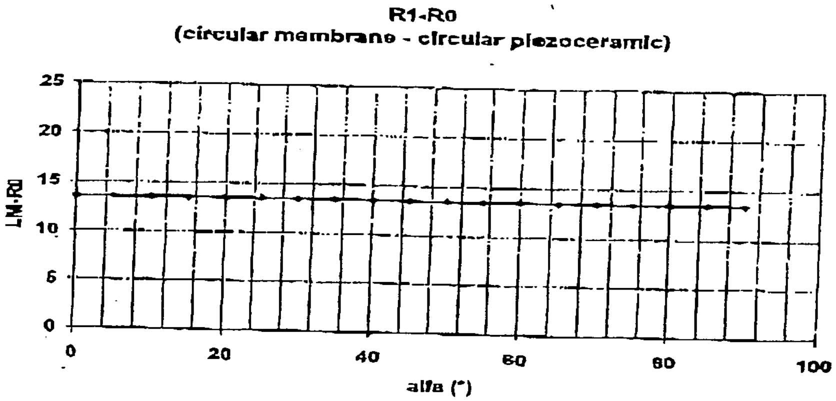
Graph I



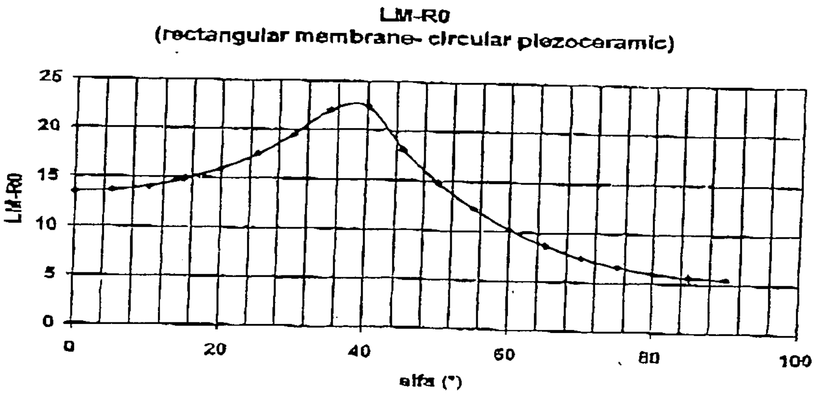
Graph II


%Total Harmonic Distortion of sample 3 (circular composite membrane) and sample 4 (rectangular composite membrane)

Graph III


R1-R0
(circular membrane - circular piezoceramic)

Graph IV


LM-R0
(rectangular membrane- circular piezoceramic)

Graph V